HOW TO MAKE WALKIE-TALKIES

FOR LICENSED OPERATION

by

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PRACTICAL WORKING CIRCUIT DIAGRAMS FOR THE HOME CONSTRUCTOR, TOGETHER WITH EXPLANATIONS ON PERMITTED USE AND OPERATING HINTS.

Gerald Myers PUBLICATIONS

THE WALKIE TALKIE

Walkie talkie was a name coined many years ago to describe a portable radio telephone which being operated by batteries could be carried by one person to communicate with someone possessing a similar device. Having obvious advantages, these instruments soon became associated with the police and the military where high speed communication is essential.

Very high frequencies are chosen because the so-called short waves are already crowded with powerful stations and because at VHF much shorter aerials mean portability is a working proposition.

Most modern VHF and UHF commercial radio telephones operate between a fixed base station, often advantageously situated at a high location, and motor vehicles travelling about within the service area of the headquarter's station. Remotely sited slave stations are sometimes employed to extend the area in which communication can be maintained. As this branch of VHF communication is not within the purpose of this booklet, it will not be enlarged upon; most being aware of its use by police, fire brigades, ambulance services as well as taxis, water, gas and electricity boards, buses and even television service firms.

The above applications differ from the walkie talkie in that two frequencies are often used, one for the base station's transmitter and another for all the out stations. This means the base station can hear all the out stations and can transmit to them but these cannot communicate with each other, but must always contact the base station.

In the walkie talkie however both transmitter and receiver operate at one fixed frequency; this means that they must be made in pairs accurately tuned to each other's frequency.

Although not seen in quite the same number as other radio systems, obvious uses for the walkie talkie are on building sites and by surveyors and explorers.

AMATEUR USE

Up until recently, Japanese made walkie talkies have been on sale cheaply but because unlicensed operation of radio transmitters is strictly forbidden in this country, their import has now been withdrawn. These were made for the American citizens' band and employed simple circuitry, much of which was common to both receiver and transmitter at a frequency of about 27MHz. In Britain, no citizens' band exists and 27MHz is a frequency not licenced for voice communication use. The licenced radio amateur is permitted to use VHF portable equipment but must pass an examination before a licence can be issued. To operate a radio station on short waves, known as the HF bands where long distance communication is possible, the licensee must have passed not only the C & G radio amateur's exam, but a morse test set either by the MPT or a coastal radio station. A class B licence is now issued where the licencee is not required to have passed a morse test, but operation is restricted to the VHF bands, that is, frequencies above 144MHz. This has proved very popular, giving a huge boost to both fixed and portable VHF experimentation and operation.

The circuits to be discussed will all centre round the 2 metre band, 144 - 146MHz., although only simple changes are necessary to place them on other frequencies such as the aircraft band.

RECEIVERS

Receivers will firstly be examined and separately, as some might wish to construct their own in order to listen in to what is going on at very high frequencies.

One of the oldest forms of VHF receiver is the super regenerative detector known affectionately as the swoosh-box. Considering its simplicity, it is very sensitive but suffers the disadvantage of only fair selectivity and the fact that it radiates radio energy, which if steps are not taken, can cause interference to other radio receivers. Never-the-less this device has many devotees and

there is hardly an amateur constructor who at some time has not had a go at a swoosh-box. The lower priced Japanese walkie-talkies mentioned above used super regenerative receivers which by simple switching, became single transistor transmitters.

Whilst a true walkie-talkie receiver is set to a fixed channel, the circuits now offered have been made tunable as it is considered most home constructors will want to spy onto other frequencies to find what is happening. One can always make a mark or some notch on the tuning scale to locate the transmitter's own frequency. When transmitters are discussed, single channel crystal control will only be shown because not only is stable variable tuning fairly complicated at VHF, but licence conditions state that when tunable transmitters are used, accurate frequency measuring equipment must be at hand. This rather precludes the use of portable apparatus of the type in which we are interested.

Super regenerative receiver.

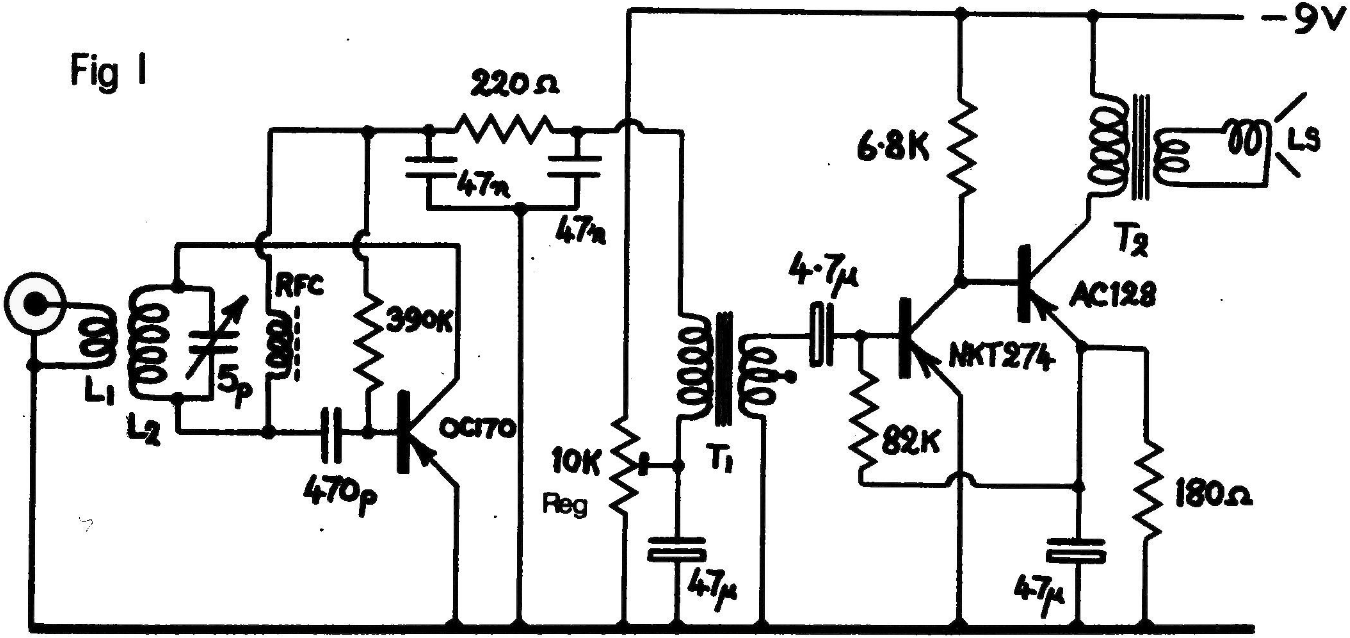
The circuit of Fig 1 is as simple as can be imagined; it uses germanium transistors and yet is capable of surprising results. One transistor type OC170 plus a handful of components followed by a simple audio amplifier is all that is necessary to receive your first VHF signals. A PP3 9V battery provides sufficient power for prolonged use.

A similar circuit, this time employing silicon transistors is shown in Fig 2; the performance of both circuits will be almost alike.

The pre-set regeneration control should only be advanced sufficiently to maintain satisfactory oscillation, indicated by a smooth rushing noise, from which the swoosh-box gets its name. A harsh sounding hiss is undesirable and indicates a too high voltage setting where sensitivity is poor.

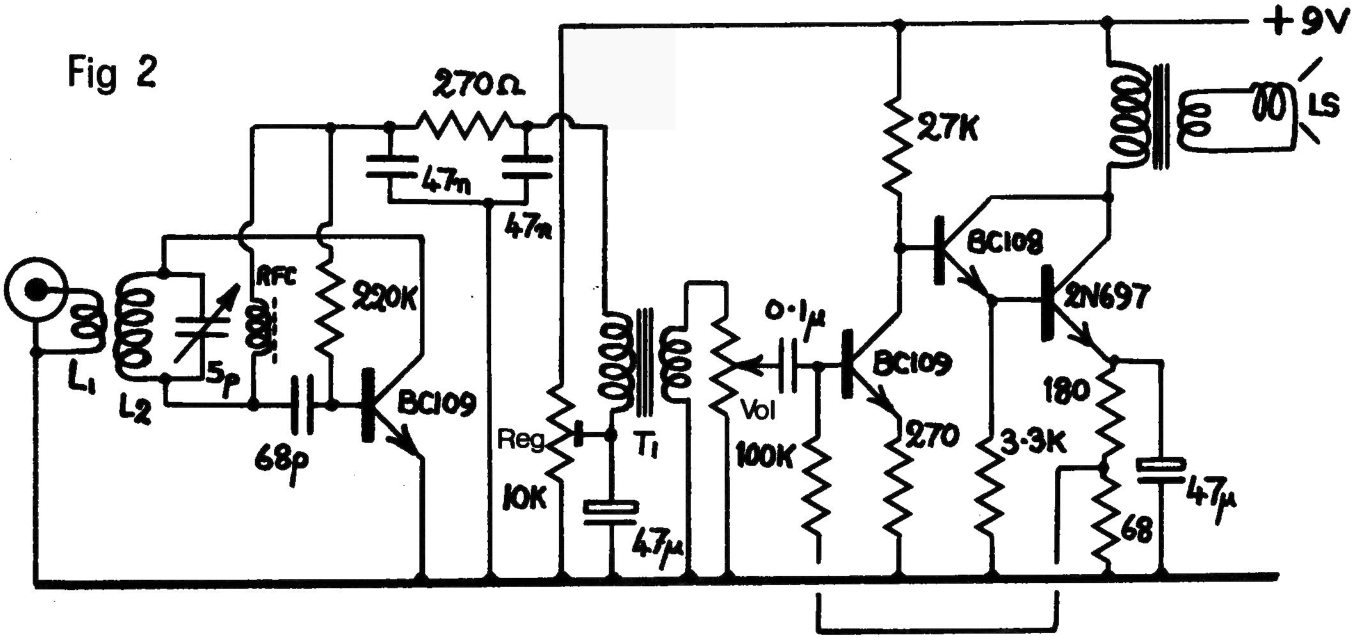
These circuits will enable the listener to sample the activity at 'HF and as few components are involved, a receiver which takes up ery little space can be constructed, in fact a breast pocket receiver.

Fig I



Simple Germanium Super-regen.

Fig 2



Silicon Super-regen Receiver

In the circuits of Fig 1 and Fig 2, the tuning capacitor is a miniature 5pF variable having one moving vane and one or perhaps two fixed vanes. The RF choke can be made by winding some 30 SWG enamel between the threads of an iron dust core, then doping in cellulose for permanence. Alternatively about three turns of similar wire may be wound onto a ferrite bead, this being as good and much smaller.

A small 10mm printed circuit type pre-set resistor would be in order for the regeneration control as once set, may be left alone. The interstage coupling transformer is a P-P transistor driver type; its secondary centre tap being neglected. Similarly the output transformer's primary centre tap is not used. These transformers are sold in pairs or can be obtained by removing from discarded miniature transistor radios; here a matching loudspeaker would also be found.

A link coil consisting of two turns of thin PVC wire is wound over L2 the tuned winding, its ends twisted together, one being taken to the aerial socket inner connector, the other to its outer contact or earth tag.

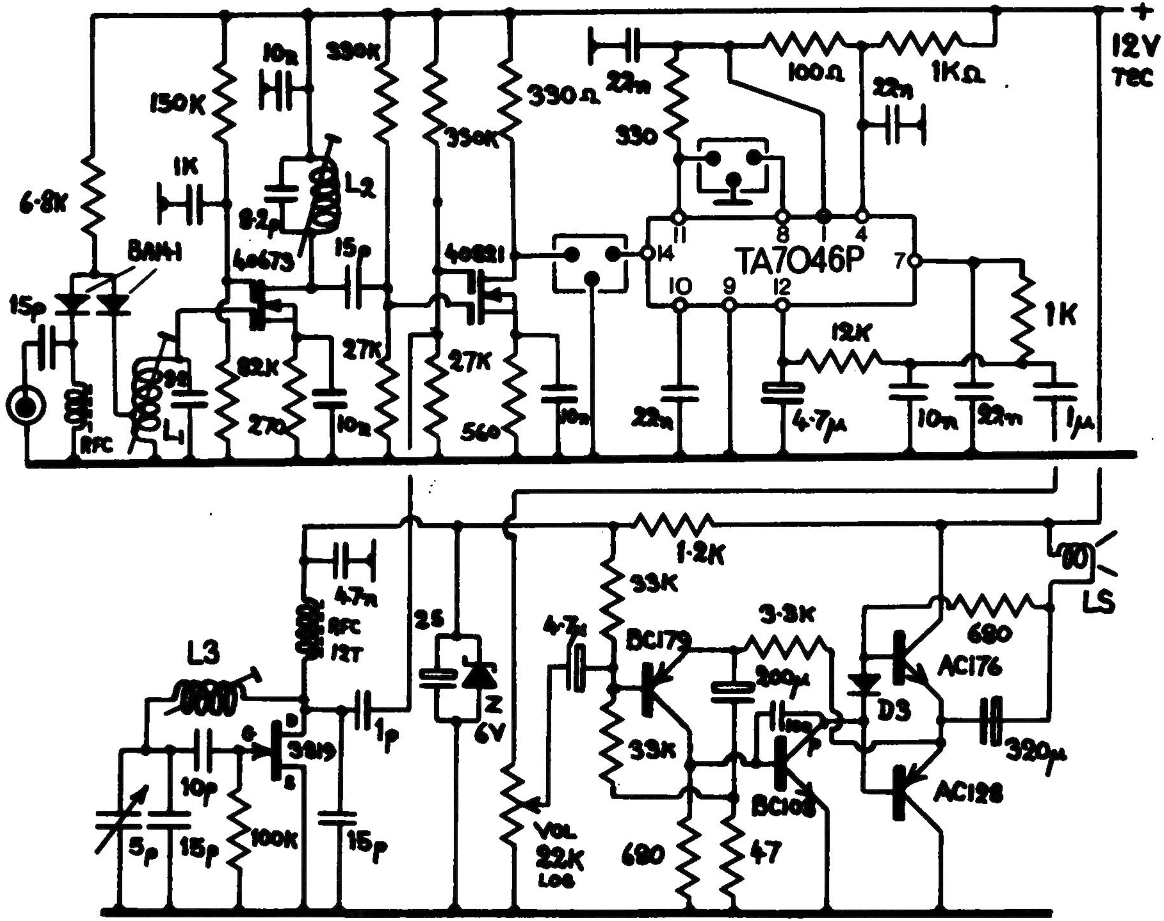
The Superhet.

The serious commercial walkie-talkie designer and the more ambitious amateur would regard the swoosh-box as merely an interesting curiosity, the super heterodyne receiver being universal.

Both single and double conversion receivers are illustrated: Fig 3 shows the first workable circuit and as stated above, crystal controlled fixed channel working would be normal in this type of circuit but we have made tuning possible for greater interest.

Single conversion and in fact double conversion where the first conversion oscillator is tunable requires careful layout and choice of components to maintain frequency stability.

One RF amplifier employing a dual gate MOSFET is tuned to signal or incoming frequency. This is followed by a further MOSFET as mixer. Here the output from the local oscillator is mixed with the



3 Single conversion receiver.

signal and their difference frequency, 10.7MHz selected by the first filter F1. These two stages should be screened from each other and wiring kept as short as possible.

An integrated circuit containing IF amplifier, detector, and AGC follows the mixer and only consumes 6.5mAs. The audio amplifier doubles as transmitter modulator.

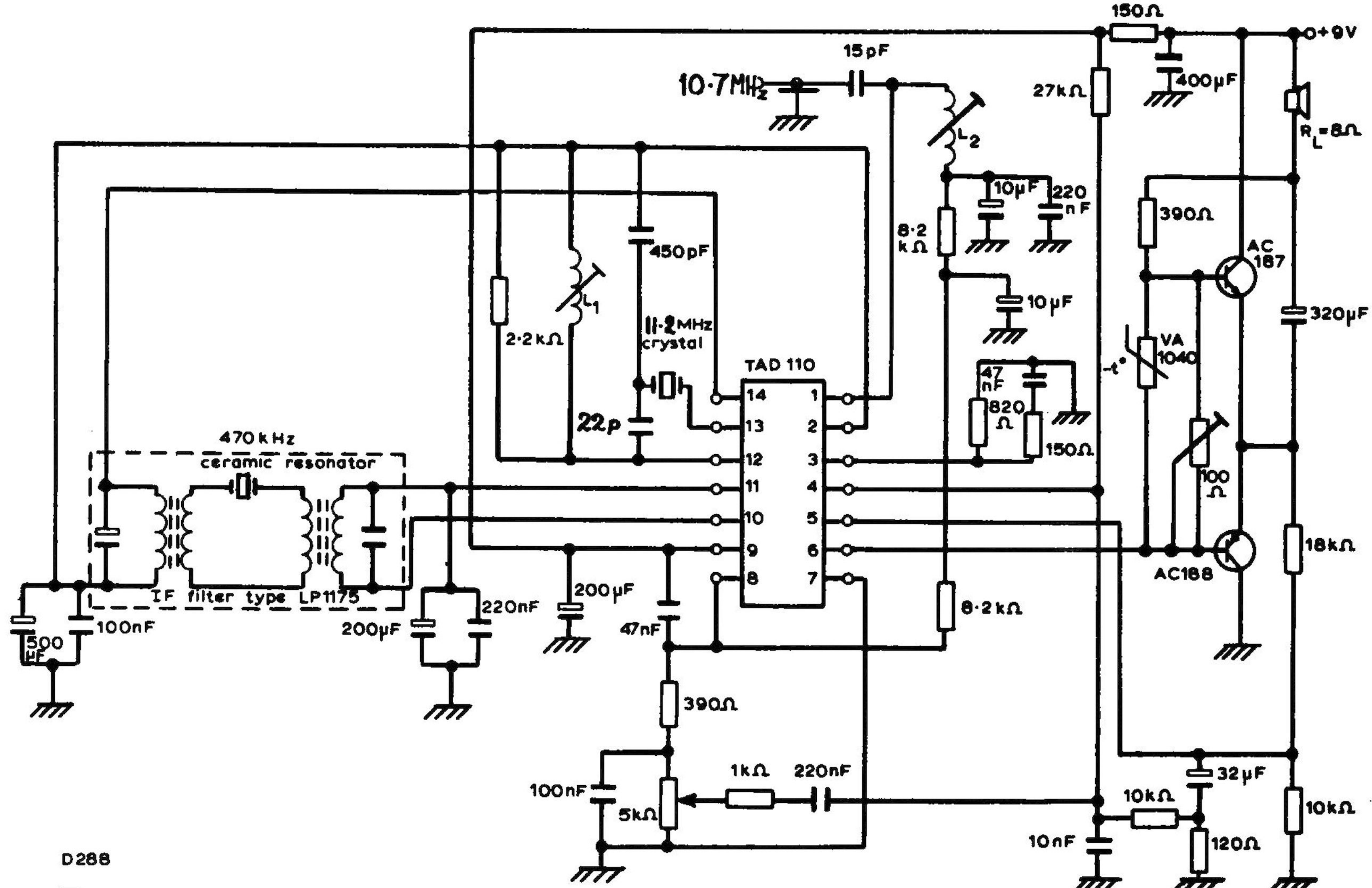
A second 10.7MHz ceramic filter connects between first and second sections of the IF amplifier, brought out to pins of the integrated circuit. A number of other integrated circuits are now available which will fulfil this function, many are made specially for frequency modulation reception. e.g., C-042-p.

Fig 4 shows the second half of a double conversion receiver whose front end or first conversion section is exactly the same as in Fig 3. Here again an integrated circuit is used, this time a crystal controlled oscillator and mixer is built in as part of the IC. Most of the audio amplifier is included in the IC except the two output transistors, which with only a handful of other components makes a very compact receiver.

In this circuit, second IF response is shaped by a 455KHz ceramic block filter again minimizing effort during alignment. The oscillator coil is wound on a 4mm former with ferrite slug.

Because of stability considerations, the circuit of Fig 5 is more popular, using the tunable IF approach. Here the front end converter section is crystal controlled to obtain high stability where it is most difficult otherwise, and the second conversion is made tunable where there is less likelihood of drift occurring. The three gang tuning capacitor now necessary, unfortunately takes up more room, but it is possible to build a receiver of this kind on a printed board 3·6" x 2·4".

Diodes D1, D2 form part of the solid state aerial switch, conducting when fed by the receiver HT supply through a 6.8K resistor. On transmit, the DC is removed and the diodes no longer conduct and being back to back, present a high resistance blocking



D288

Fig 4 Second conversion section.

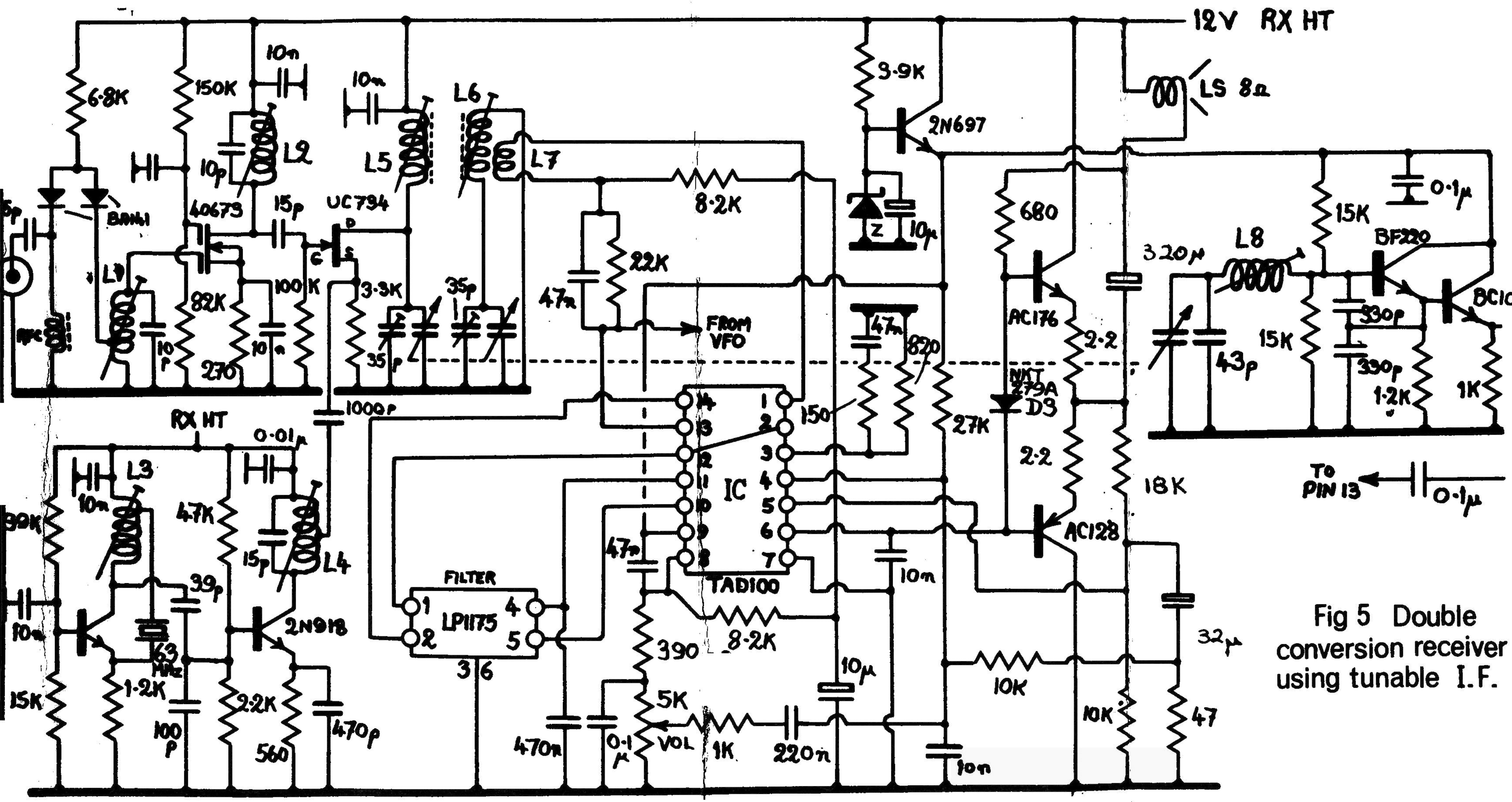


Fig 5 Double conversion receiver using tunable I.F.

the transmitter's energy from reaching the receiver RF stage. Here again a dual gate MOSFET is tuned to signal frequency; coils L1 and L2 wound with four turns of 22 SWG tinned copper wire on 3/16" formers, these fitted with iron dust VHF slugs.

The mixer this time is a junction FET, oscillator injection fed to its source from a centre tap on the doubler coil L4. An overtone type crystal oscillator operates at 63MHz; its coil, L3 has 5 turns of 22 SWG tinned copper wire on a 3/16" former. A second transistor in the chain doubles the oscillator frequency to 126MHz, its coil having 4 turns of similar wire, also on a 3/16" former. VHF dust slugs are fitted to both coils.

Covering approximately 18 - 20 MHz, the tunable IF coils are spaced 0.45" and wound with 20 turns of 32 SWG, close wound, again on 3/16" formers. On top of L6 is wound a five turn link coil to couple into the integrated circuit. This may be of thicker wire, say 28 SWG.

External to the IC for stability reasons, a Clapp type variable oscillator with emitter follower injects into the second mixer at pin 13 of the IC. The VFO coil L8 has 19 turns of 32 SWG close wound on a 3/16" former which must be housed inside a ½" x ½" screening can to prevent whistles and birdies, the dust slug accessible through a small hole in the top.

A single ceramic block filter at 455KHz determines the second IF selectivity, avoiding lengthy alignment procedure. Two germanium transistors complete the audio amplifier with a single diode D3 providing their bias. The IC requires 6V which is provided by a simple stabilizer from a zena diode reference; this supply also used for the VFO. Connected across the zena, a 1,000pF ceramic capacitor overcomes noise which sometimes occurs in such circuits; the capacity of the larger electrolytic being amplified by the gain of the transistor.

The 47 nF capacitor between pins 8 and 9 of the IC should be a subminiature type and mounted close to the IC.

Using the component values stated, the 17+17+20pF three gang VHF tuning capacitor will tune exactly the 144 - 146MHz amateur band.

This receiver together with a transmitter based on the following circuit has been used successfully to communicate with stations on the continent of Europe; 5 - 9 (loud and clear) both ways.

Not remarked upon so far is the fact ICs and FETs have been taken for granted in our designs. Modern walkie-talkies are supposed to be small and ICs make this possible without the need for excessive cramming in of bulky components. Solid state switching where possible overcomes the largest problem in reliability, namely contact wear.

Many small walkie-talkies make use of the loudspeaker as a microphone when on transmit; this calls for a considerable degree of switching which can either be mechanical or solid state. Miniature dynamic microphones are available today and used in burglar alarms; these being slim, will fit into the smallest case obviating the need for complicated switching. By not combining transmitter and receiver circuitry but building them separately, one simple single pole, two way push switch is then all that is necessary, the duplication of the audio networks being a small price compared with the complexity of mechanical or electronic switching. Servicing can be carried out without disturbing the section not requiring attention.

THE TRANSMITTER

The circuit presented is one which makes the best possible use of component economy and battery capabilities without anything being sacrificed in performance. Only three transistors are employed and crystal control adopted as at this time, anything less would be considered quite unacceptable. Gone are the days when a self excited oscillator transmitter could be put on the air without creating alarm.

An overtone type crystal oscillator, Q1, operates at half the final frequency, 72MHz. The cost of the miniature HC-18U or HC-25U crystal outweighs the cost of the extra circuitry necessary in a multiplier chain following a lower frequency crystal. The problem of removing all the unwanted harmonics inevitably generated with such a system does not arise.

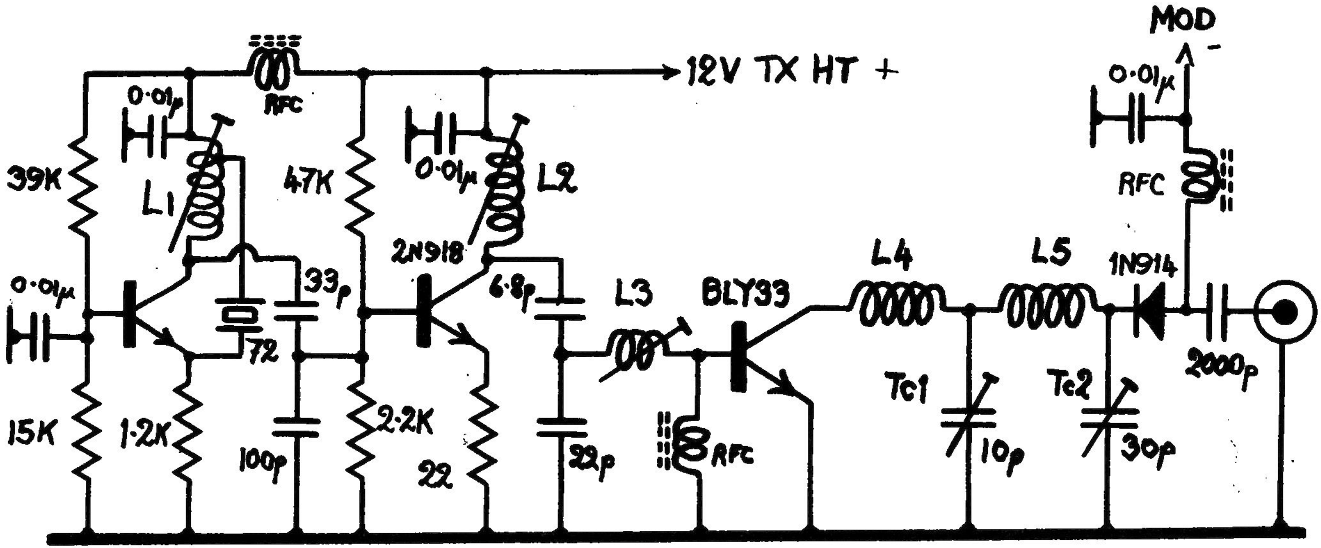


Fig 6 The Transmitter

The oscillator's collector coil has five turns of 22 SWG tinned copper wire with a tap one turn only down from its "cold" end, that is the end nearest HT supply. A 3/16" former is used with a VHF dust slug fitted.

Q2 doubles the oscillator frequency and provides sufficient amplification to drive the power stage directly. A resistive potential divider lifts the doubler's base voltage to a point just short of the onset of conduction, helping the oscillator to drive more effectively. A 22 ohm resistor in Q2 emitter controls collector current.

The doubler's collector coil has four turns of 20 SWG tinned copper wire, again on a 3/16" former with VHF slug, resonated by the series connected capacitors. The upper capacitor is a 6.8pF; the lower a 22pF, this resonating with the second coil and the inherent base capacity of Q3, the power transistor. Only 1½ turns of 20 SWG are wound on this second coil, L3, and a slug may not in fact be needed.

Keeping as short as possible, an RF choke consisting of two turns of enamel wire on an FX1115 ferrite bead is connected between Q3 base and earth where its emitter connects. Q3 emitter lead should be no longer than 2mm, soldered to the upper surface of the double sided printed board. Between each stage a screen should be fitted, soldered to the PC board's upper surface.

A heat radiating clip or fin must be fitted to Q3. An L-Pi network couples the PA collector to the aerial outlet. No slugs are fitted to the two coils in this network, a 10pF trimmer is used to resonate the first section and acts also on the second in conjunction with the larger 30pF loading trimmer. In series with both the signal path and the DC supply to the PA transistor is a diode which when not conducting during receive, forms a high resistance block or isolation between receiver and transmitter tuned circuits. The RF choke feeding the HT from modulation transformer to the PA is again a two turn winding on a ferrite bead.

Readers will note how few components are involved, yet this circuit can transmit messages far in excess of the range usually associated with walkie-talkies. Whilst the normal range will be just a few miles and up to 50 miles from a clear location, a directional aerial will increase the range during good conditions to over 200 miles.

An absorption wavemeter should be used when aligning the transmitter coils to make sure unwanted harmonics are not accidentally radiated.

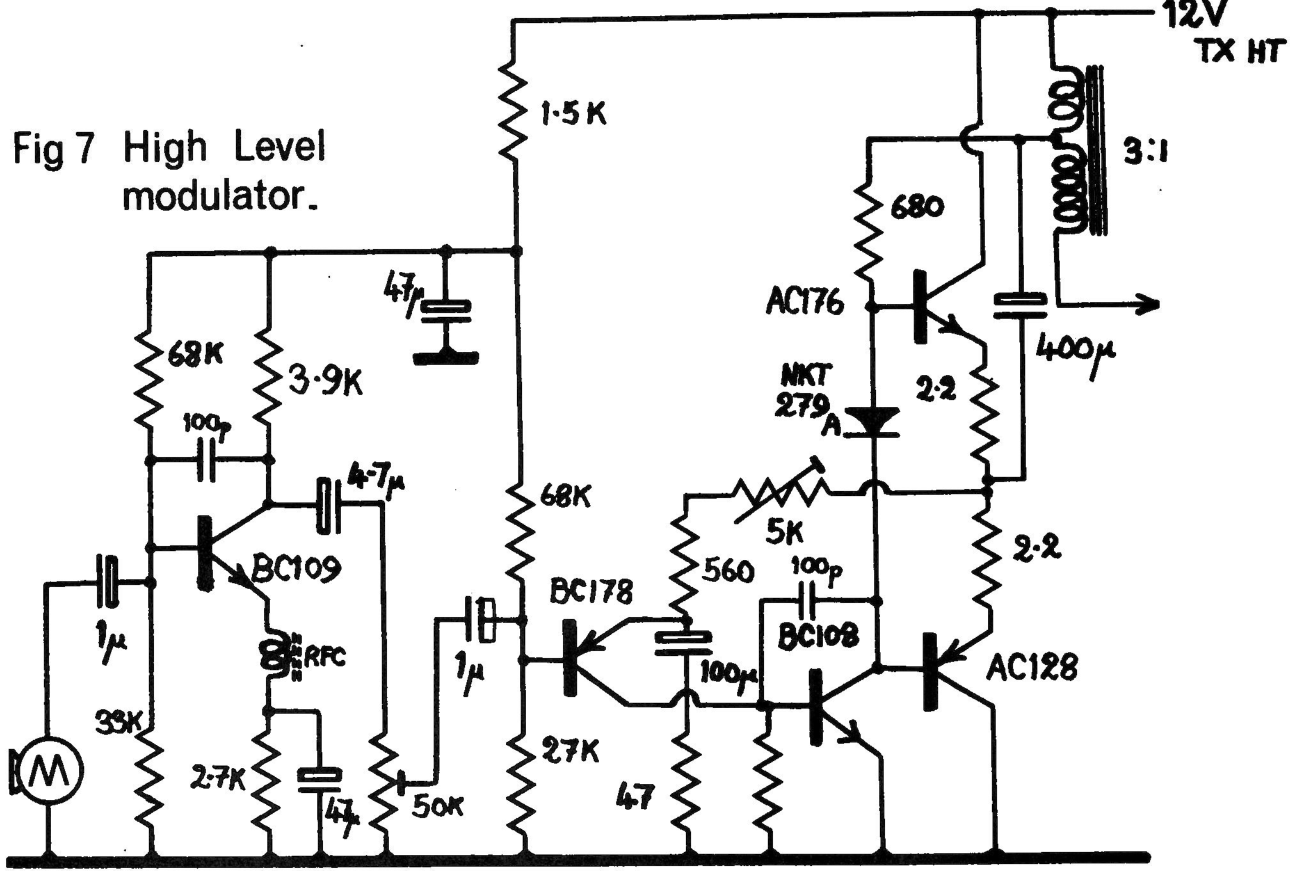
A modulation transformer of fairly small dimensions hence taking up little room will suffice in this transmitter; the core's centre limb cross sectional area being 0.114 sq" to produce excellent voice quality. A 2.5 to 3:1 step up winding is necessary when modulating from a quasi-complementary audio circuit.

Modulation

In Fig 7, a simple high level modulator is illustrated which is suitable to work in conjunction with the transmitter described. Readers will note the similarity between this circuit and the audio stage of the receiver of Fig 3; this is why some constructors will favour switching to avoid duplication. Heat conduction clips should be fitted to the two germanium output transistors.

No special conditions must be met in the modulator's construction, the two pre-set resistors are adjusted as follows: Vr2 may be set simply by adjusting until the voltage at the mid-point between the two 2.2 ohm resistors is half the HT supply value, i.e., 6V. Vr1 is then advanced until satisfactory modulation is reached as heard in a monitor receiver. It is better however to make these adjustments with the aid of audio signal generator and oscilloscope. The 'scope is connected between either the transformer tap or feed to PA and earth. Setting its output to some 5 or 10 mV, the generator is connected across the microphone terminals and Vr1 advanced until the waveform is seen to clip. Vr2 is now adjusted so that the wave form clips equally top and bottom. Removing the

Fig 7 High Level modulator.



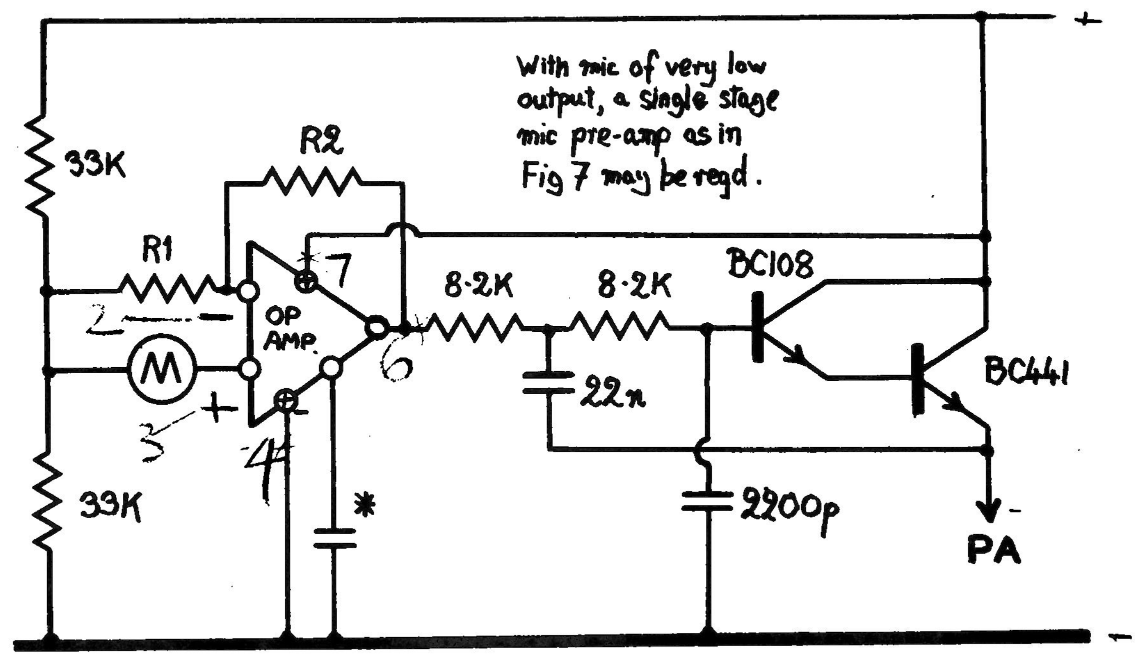


Fig 8 Series modulator

generator and speaking in a normal voice into the microphone, Vr1 is adjusted finally so that only voice peaks cause any sign of clipping.

A much simpler circuit has been suggested employing a series modulator which obviates the necessity of a modulation transformer. A high gain operational amplifier is adjusted so that its output completely clips off all the speech peaks giving more effective voice power. As the ratio of R2 to R1 control the gain of this circuit, these resistors must be chosen to suit the microphone selected. Should the heavily clipped output be fed directly to the modulator, distortion products well into and beyond the audio range would be transmitted causing an undesirable spread either side of the transmission channel. A simple but effective low pass filter built around the compound current amplifier forming the series modulator, rapidly attenuates signals above 3KHz resulting in clean modulation with added 'talk power'.

The use of this circuit however reduces the transmitter output from 400 mW to 100 mW. This is not as serious as at first might be thought. At the receiver the signal will be one 'S' point or 6 db down when compared with the 400 mW circuit, but, the improved modulation system conveying the same intelligence together with a huge saving in battery consumption make this system very attractive.

If the microphone is to be separate, a multicore flex must be obtained or constructed. A single core screened wire for the mic., signal plus three thin flexible stranded PVC wires all threaded through a heavy outer can be home constructed. Low loss coaxial cable with its inner core extracted is ideal; the outer braid if left in acts as an extra screen and should be soldered to the plugs outer shell. With a microphone built into the case, this last may be ignored.

AERIALS AND OPERATING

Normal day to day short haul communication requires only the simplest of aerials: a quarter wave whip, which for the 144 - 146 MHz band should be cut to 19" in length. Fold-away telescope whips are plentiful today and may either be permanently fitted to the set or equipped with a coax plug, removed when a higher gain aerial is required.

When operating from a fixed location, an omni-directional aerial may be mounted high up and fed with a coaxial cable; ordinary TV type 75 ohm or low loss cable is satisfactory. An assortment of aerials to obtain all round coverage have been tried: the ground plane, a familiar sight around airports; 5/8 whips on vehicles, and vertically polarised dipoles. Commercially the weather proofed co-linear is now much in evidence where the ground plane was once dominant.

For reasons perhaps lost in tradition, radio amateurs adopted horizontal polarization for VHF communication where less choice exists in aerial arrays. The halo is the most popular aerial in use but tests suggest the turnstile or crossed dipoles give superior performance.

Long range communication demands a directional aerial giving gain over the systems mentioned so far. The Yagi parasitic array is by far the commonest aerial of all time, being extensively employed for both communication and entertainment, TV and FM broadcast services. The Yagi can be mounted to give vertical or horizontal polarization; by increasing the number of elements, gain is increased but beamwidth and bandwidth becomes sharpened. Aerials may be stacked one above the other to produce extra gain but most of all added bandwidth.

The cubical quad, very popular on the short waves for long distance work (DX) has been found to perform excellently at VHF also. A two element quad, that is one with driven element and reflector can be made collapsible, folding like an umbrella, is convenient for portable work. A four element cubical quad having two directors will give highly superior performance comparable with a ten element Yagi yet only four feet in boom length at this frequency. A little ingenuity should make possible a fold up version of this aerial. The driven element should be 20" on all sides fed with 75 ohm coax at the centre of the lower leg; the reflector 21" on all sides with no breaks; the first director 19" and again completely solid, the second director perhaps slightly shorter, say 18½" on each side. Spacing between elements is 16".

It must be remembered as these aerials are very directional, they must point in the direction of the station to be received; some

means of revolving them easily, either by hand or with a motor must be considered where the out station is likely to move about, as with a walkie-talkie.

Walkie-talkie users can assist in ensuring reliable communication by making sure where ever possible, a high location or at least one with a clear "take off" is used as this will increase the range noticeably.

Tall buildings can reduce contact reliability but hills and mountains often form a complete block. When positioned on a hill, the side facing the wanted station's direction just below the top is found to be better than the actual summit especially when using simple aerials such as the whip. A modest hillock aided by even small directional aerial such as the two element quad will produce a range of 200 miles during fair to good conditions.

Signal reports usually quote readability and strength.

R5	perfectly readable.
R4	slight difficulty in copying every word.
R3	many words being missed.
R2	almost unreadable.
R1	voice heard but intelligence impossible to resolve.

S9	very strong signals.
S8	strong signals.
S7	fair signal strength.
S6	adequate signals.
S5	weaker but still adequate strength.
S4	poor signal strength.
S3	weak signal
S2	signals detectable but very weak.
S1	signals almost undetectable.

When either calling or passing the transmission to the other station, always give his call sign first and yours last. Sometimes more than two and in fact a whole group of stations might assemble on the one frequency forming a net; the word net means all on one frequency despite its frequent misuse. Here when passing transmission to the next to speak, read his callsign first, the other members of the net next, finally your own callsign. It becomes clear to all then who is next to speak and the identity of the station who has just spoken.

Try to avoid the habit of "um" and "er", saying what is necessary concisely, paying attention to detail; there could be an emergency where reliable radio communication could save lives. Less dramatically, prolonged transmissions soon use up battery power. Receivers tend to be economical on battery consumption but even low power transmitters burn up power very quickly. Dry batteries tend to have a very limited life, frequent replacement becoming costly. Re-chargeable batteries cost much more initially but pay for themselves over just a few weeks. Lead-acid batteries can easily leak disastrously, although fully sealed jelly ones are manufactured. By far the most satisfactory is the nickel-cadmium cell. These are expensive but last a very long time. A socket mounted in say a side wall of the walkie-talkie will enable a charger to be connected after use so that the set is ready for use the next time.

THE END

The publisher invites authors, either new or with previous experience to submit their work for publication. The work may deal with any facet of electronics but must always be of a practical nature. All circuits & diagrams should be thoroughly checked before submission for publication.
If you intend trying your hand at this type of work, it is suggested that you complete a short summary of the subject that you intend to cover. The size of your book can then be determined and advice given on presentation.